ESM 121

Water Science
and Management

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Exercise 6:

Flow Regime Analysis

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Objective

The aim of this tutorial is to gain a general understanding of how to use the Indicators for Hydrologic Alteration (IHA) software to evaluate pre- and post-altered flow regimes. The flow regime in the American River, prior and after the construction of the Folsom Dam, is used as case study.

Introduction

The American River in runs 119 miles (192 km) from its headwaters in the Sierra Nevada to its confluence with the Sacramento River, in Sacramento, CA. As part of the Central Valley Project, the Folsom Dam was constructed in 1956 for the purposes of flood control, hydroelectricity, and irrigation and municipal water supply. We will be using the IHA software to analyze flow data below the Folsom Dam at the USGS Fair Oaks stream gage.

Figure 1: American River

Software Download and Data

• Unzip the tutorial zip file, which contains both the IHA software and the American River USGS stream gage data from Fair Oaks, CA.

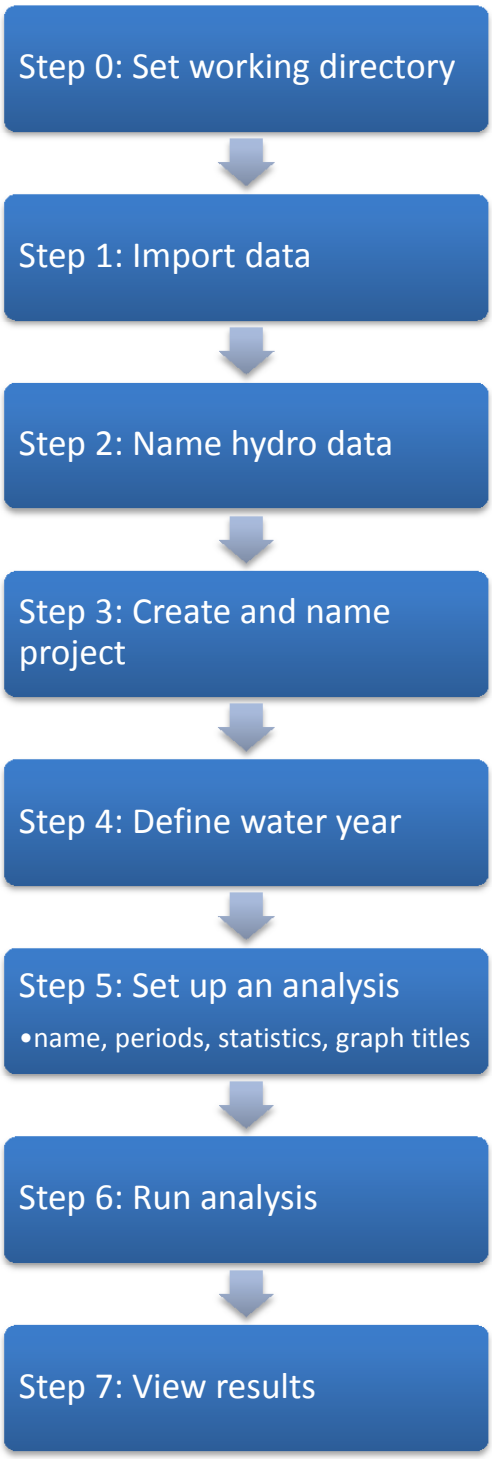
NOTE: The folder also contains files for another IHA tutorial included with the software that will NOT be used in this tutorial. The tutorial you are doing now has been tailored for analysis of a California relevant river system.

The IHA software is also available for download from The Nature Conservancy website.

http://www.conservationgateway.org/ConservationPractices/Freshwater/EnvironmentalFlows/MethodsandTools/IndicatorsofHydrologicAlteration/Pages/IHA-Software-Download.aspx

Analysis Setup Overview

The following is an overview of the basic steps taken to complete an IHA analysis.


Step 0: Set working directory
Step 1: Import data
Step 2: Name hydro data
Step 3: Create and name project
Step 4: Define water year
Step 5: Set up an analysis
•name, periods, statistics, graph titles
Step 6: Run analysis
Step 7: View results

Project and Analysis Setup Steps

This section will walk you through the IHA wizard, in which you will import the "FairOaks.txt" stream gage data, then set up and run an analysis.

• In the unzipped "IHA71_En" folder, double-click on the IHA7 application to run the software.

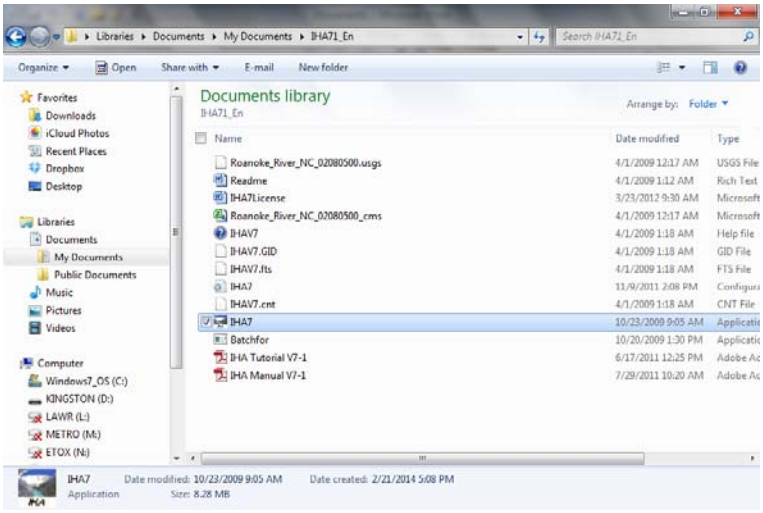


Figure 2

• You will see the following window below. Click cancel. Before running the wizard, a working directory needs to be set. If this is not done, the software will give remind you to do so before starting an analysis.

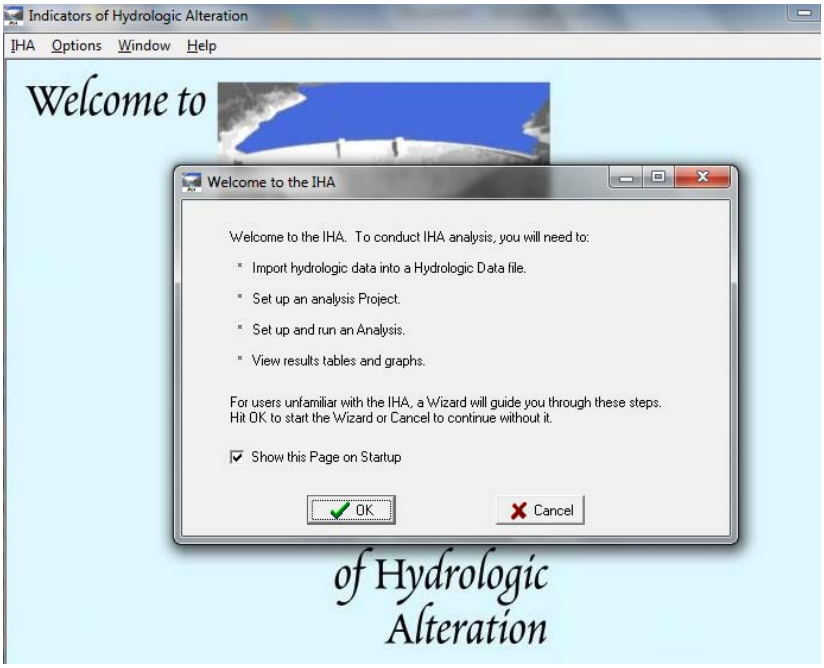

Indicators of Hydrologic Alteration
IHA Options Window Help
Welcome to
Welcome to the IHA
Welcome to the IHA. To conduct IHA analysis, you will need to:
* Import hydrologic data into a Hydrologic Data file.
* Set up an analysis Project.
* Set up and run an Analysis.
* View results tables and graphs.
For users unfamiliar with the IHA, a Wizard will guide you through these steps.
Hit OK to start the Wizard or Cancel to continue without it.
Show this Page on Startup
OK
Cancel
of Hydrologic
Alteration

Figure 3

•**IMPORTANT STEP 0**. Go to the Options menu and select "Set Working Directory." Set your working directory to the "IHA71_En" folder.

• **STEP 1.** Now you are ready to run the wizard. Under the IHA menu, select "Wizard." The window (Figure 4) will appear. Select OK for the next two windows to start the import process.

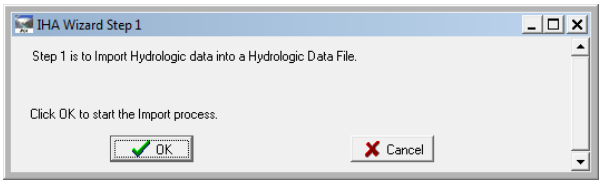

IHA Wizard Step 1
Step 1 is to Import Hydrologic data into a Hydrologic Data File.
Click OK to start the Import process.
OK
Cancel

Figure 4

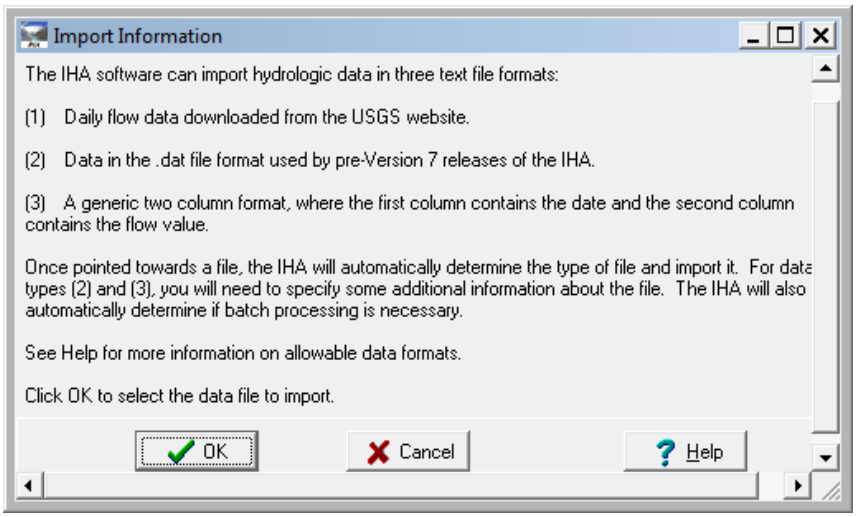

Import Information
The IHA software can import hydrologic data in three text file formats:
(1) Daily flow data downloaded from the USGS website.
(2) Data in the .dat file format used by pre-Version 7 releases of the IHA.
(3) A generic two column format, where the first column contains the date and the second column contains the flow value.
Once pointed towards a file, the IHA will automatically determine the type of file and import it. For data types (2) and (3), you will need to specify some additional information about the file. The IHA will also automatically determine if batch processing is necessary.
See Help for more information on allowable data formats.
Click OK to select the data file to import.
OK
Cancel
Help

Figure 5

• Browse to the "FairOaks.txt" file provided with this tutorial. In the Import Dialog, select "Use all data" and "cfs (cubic feet per second)," then click OK.

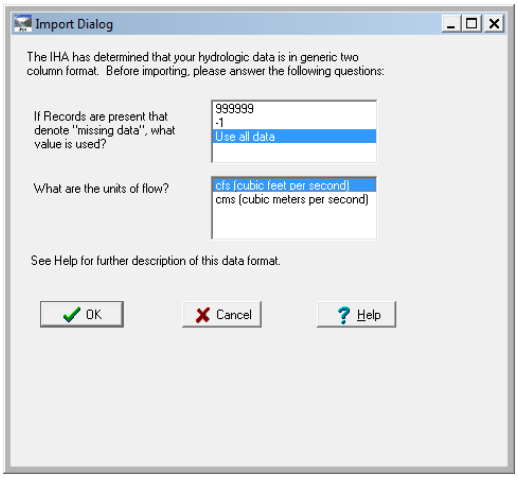

Import Dialog
The IHA has determined that your hydrologic data is in generic two column format. Before importing, please answer the following questions:
If Records are present that denote "missing data", what value is used?
999999
-1
Use all data
What are the units of flow?
cfs (cubic feet per second)
cms (cubic meters per second)
See Help for further description of this data format.
OK
Cancel
Help

Figure 6

• **STEP 2.** Click OK to name your Hydro Data File "FairOaks." While this tutorial only uses one data set, multiple data sets can be added to your project.

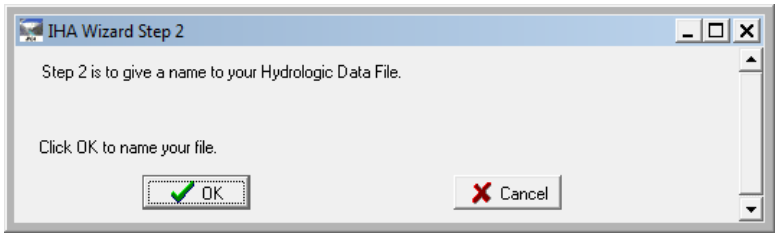


Figure 7

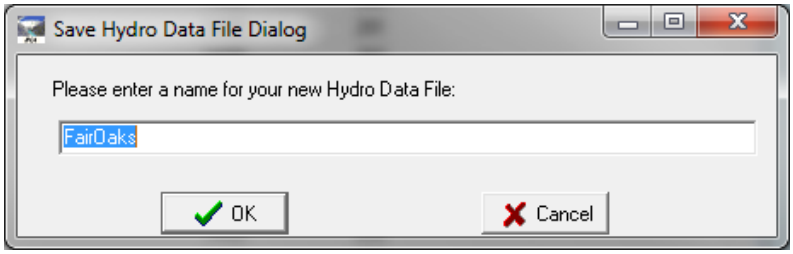


Figure 8

• **STEP 3.** Click OK to create an analysis Project that is linked to your Hydro Data file and name it "AmericanRiverProject."

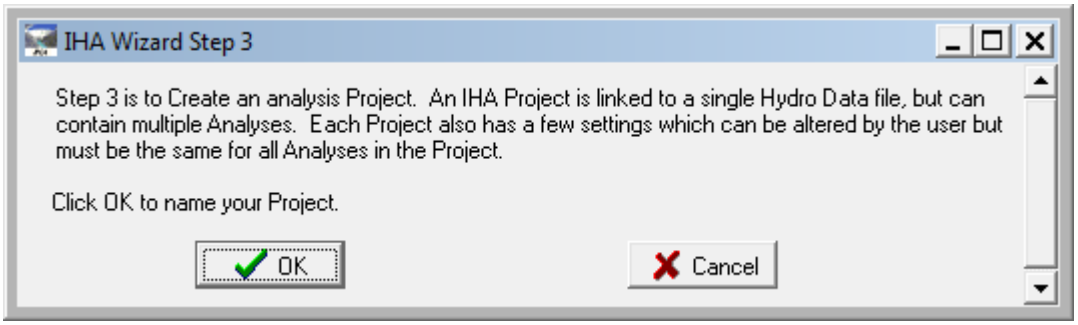

IHA Wizard Step 3
Step 3 is to Create an analysis Project. An IHA Project is linked to a single Hydro Data file, but can contain multiple Analyses. Each Project also has a few settings which can be altered by the user but must be the same for all Analyses in the Project.
Click OK to name your Project.
OK
Cancel

Figure 9

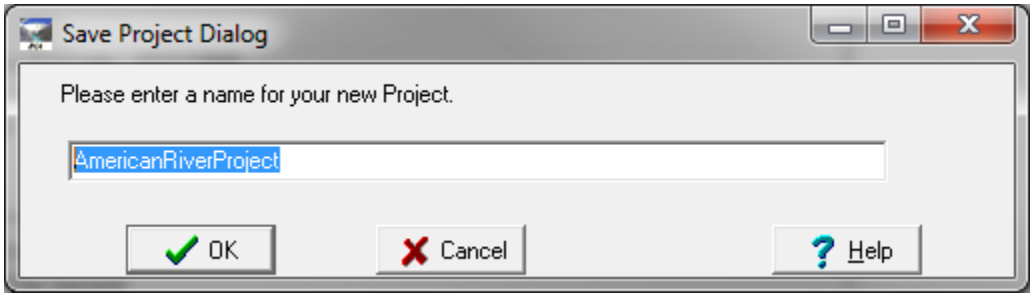


Figure 10

• **STEP 4.** Click OK to define the Water Year for this project.

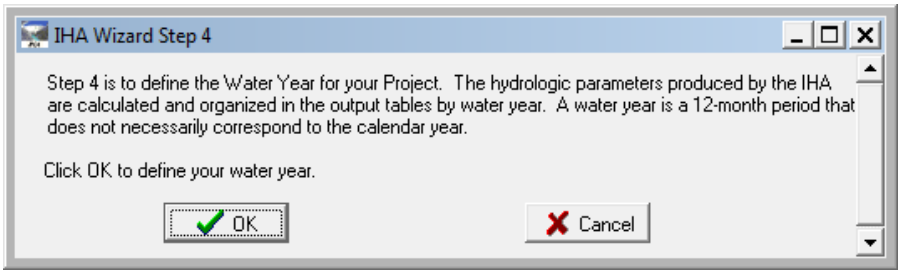

IHA Wizard Step 4
Step 4 is to define the Water Year for your Project. The hydrologic parameters produced by the IHA are calculated and organized in the output tables by water year. A water year is a 12-month period that does not necessarily correspond to the calendar year.
Click OK to define your water year.
OK
Cancel

Figure 11

• Select "Water Year 1994 = Oct. 1st 1993-Sept 30th 1994."

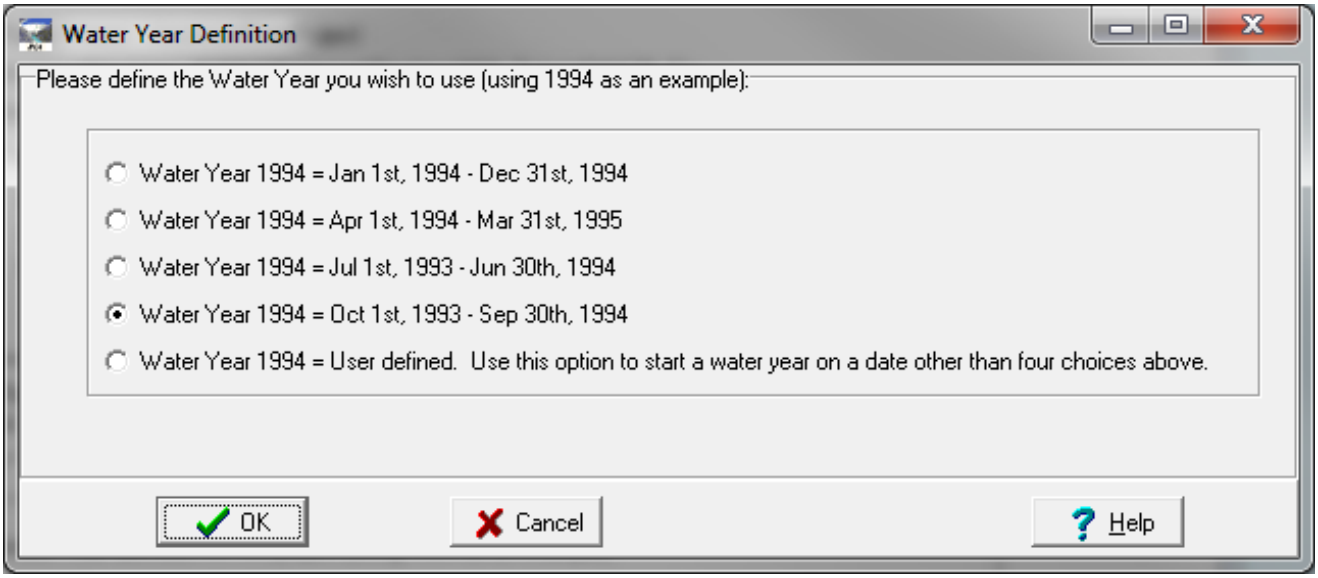

Water Year Definition
Please define the Water Year you wish to use (using 1994 as an example):
Water Year 1994 = Jan 1st, 1994 - Dec 31st, 1994
Water Year 1994 = Apr 1st, 1994 - Mar 31st, 1995
Water Year 1994 = Jul 1st, 1993 - Jun 30th, 1994
Water Year 1994 = Oct 1st, 1993 - Sep 30th, 1994
Water Year 1994 = User defined. Use this option to start a water year on a date other than four choices above.
OK
Cancel
Help

Figure 12

• **STEP 5.** Click OK to set up an Analysis within this project.

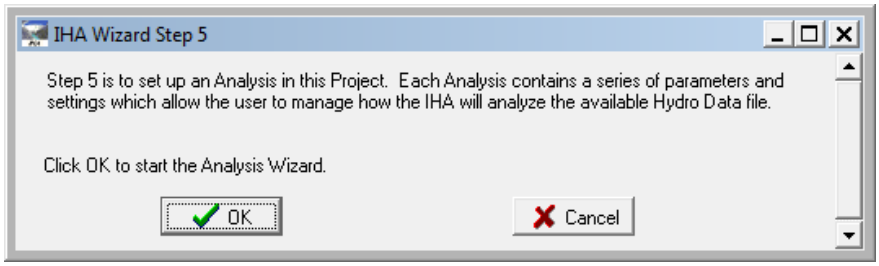

IHA Wizard Step 5
Step 5 is to set up an Analysis in this Project. Each Analysis contains a series of parameters and settings which allow the user to manage how the IHA will analyze the available Hydro Data file.
Click OK to start the Analysis Wizard.
OK
Cancel

Figure 13

• Click Next, then name your Analysis "BelowFolsomDam" and click Next.

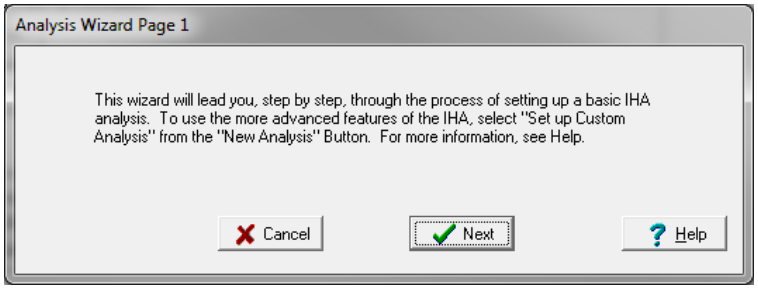

Analysis Wizard Page 1
This wizard will lead you, step by step, through the process of setting up a basic IHA analysis. To use the more advanced features of the IHA, select "Set up Custom Analysis" from the "New Analysis" Button. For more information, see Help.
Cancel
Next
Help

Figure 14

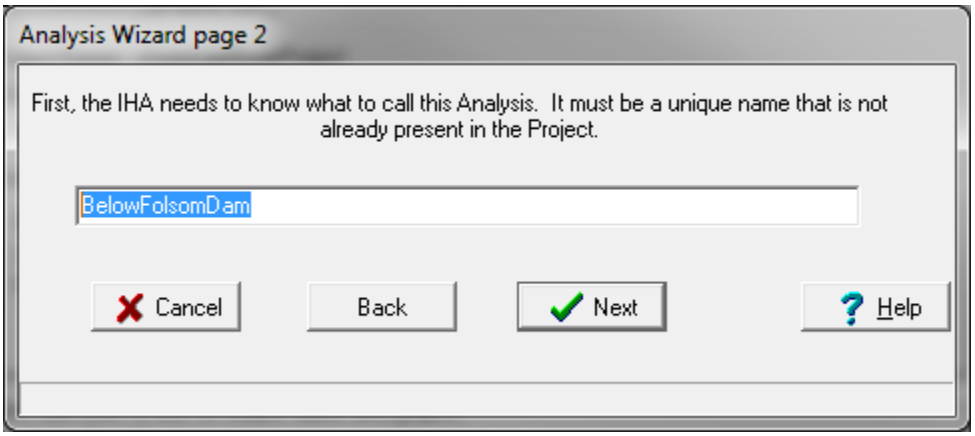

Analysis Wizard page 2
First, the IHA needs to know what to call this Analysis. It must be a unique name that is not already present in the Project.
BelowFolsomDam
Cancel
Back
Next
Help

Figure 15

This analysis will look at the impact of the construction of the Folsom Dam on the American River by comparing pre- and post- impairment periods.

• Select "Compare two periods."

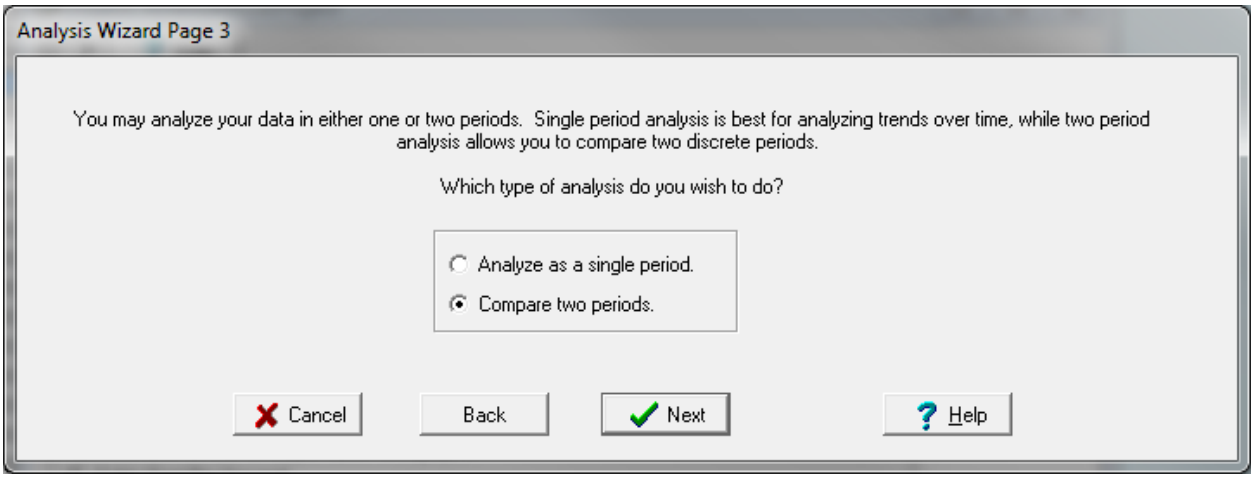

Analysis Wizard Page 3
You may analyze your data in either one or two periods. Single period analysis is best for analyzing trends over time, while two period analysis allows you to compare two discrete periods.
Which type of analysis do you wish to do?
Analyze as a single period.
Compare two periods.
Cancel
Back
Next
Help

Figure 16

Construction of the Folsom Dam was completed in 1956.

• Drag the slide control so that the time period on the left is “1905-1955” and click Next.

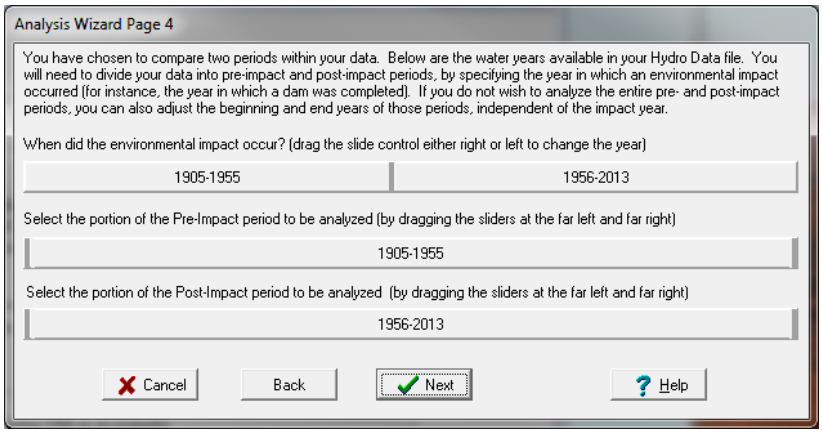

Analysis Wizard Page 4
You have chosen to compare two periods within your data. Below are the water years available in your Hydro Data file. You will need to divide your data into pre-impact and post-impact periods, by specifying the year in which an environmental impact occurred (for instance, the year in which a dam was completed). If you do not wish to analyze the entire pre- and post-impact periods, you can also adjust the beginning and end years of those periods, independent of the impact year.
When did the environmental impact occur? (drag the slide control either right or left to change the year)
1905-1955
1956-2013
Select the portion of the Pre-Impact period to be analyzed (by dragging the sliders at the far left and far right)
1905-1955
Select the portion of the Post-Impact period to be analyzed (by dragging the sliders at the far left and far right)
1956-2013
Cancel
Back
Next
Help

Figure 17

• Select “Non-Parametric Statistics” and click Next.

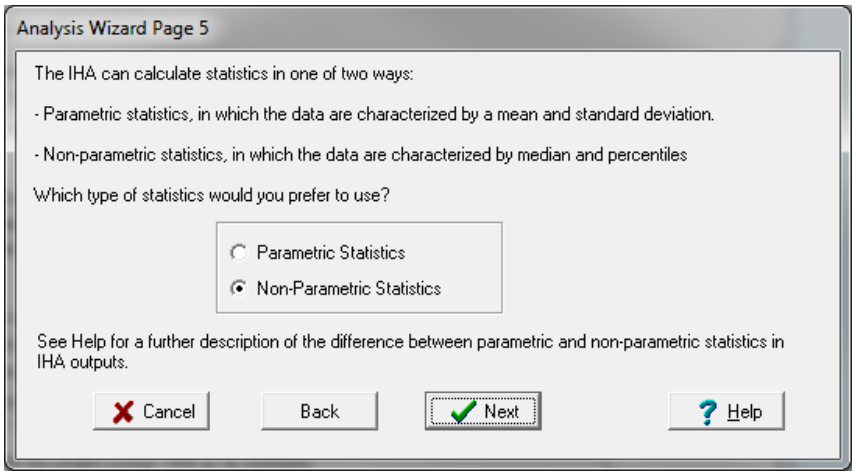

Analysis Wizard Page 5
The IHA can calculate statistics in one of two ways:
- Parametric statistics, in which the data are characterized by a mean and standard deviation.
- Non-parametric statistics, in which the data are characterized by median and percentiles
Which type of statistics would you prefer to use?
Parametric Statistics
Non-Parametric Statistics
See Help for a further description of the difference between parametric and non-parametric statistics in IHA outputs.
Cancel
Back
Next
Help

Figure 18

• Type in a title to display on the output tables and graphs, for example “American River below Folsom”

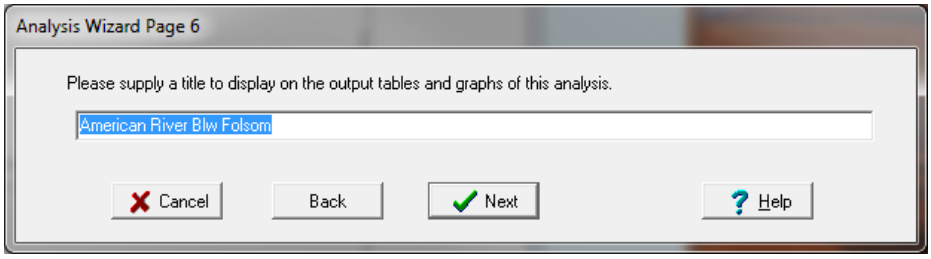


Figure 19

• The next window reminds you that there are other custom setup options available. Continue with the analysis by clicking Next.

Later in the tutorial, we will show you how to edit analysis parameters (Figure 28).

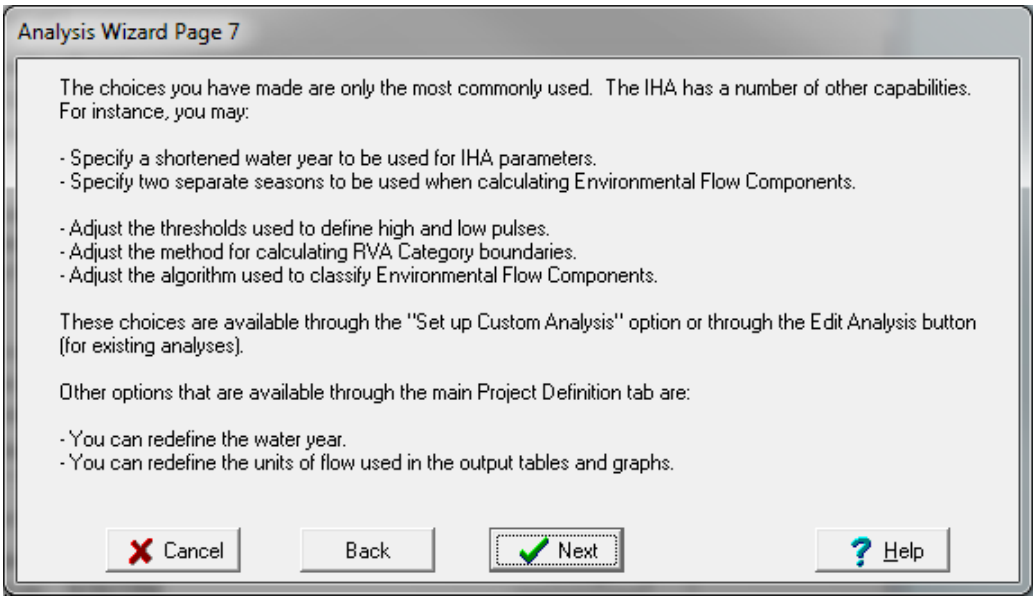

Analysis Wizard Page 7
The choices you have made are only the most commonly used. The IHA has a number of other capabilities. For instance, you may:
- Specify a shortened water year to be used for IHA parameters.
- Specify two separate seasons to be used when calculating Environmental Flow Components.
- Adjust the thresholds used to define high and low pulses.
- Adjust the method for calculating RVA Category boundaries.
- Adjust the algorithm used to classify Environmental Flow Components.
These choices are available through the "Set up Custom Analysis" option or through the Edit Analysis button (for existing analyses).
Other options that are available through the main Project Definition tab are:
- You can redefine the water year.
- You can redefine the units of flow used in the output tables and graphs.
Cancel
Back
Next
Help

Figure 20

• The window below summarizes the parameters you have selected for this analysis. Click “Save this Analysis.”

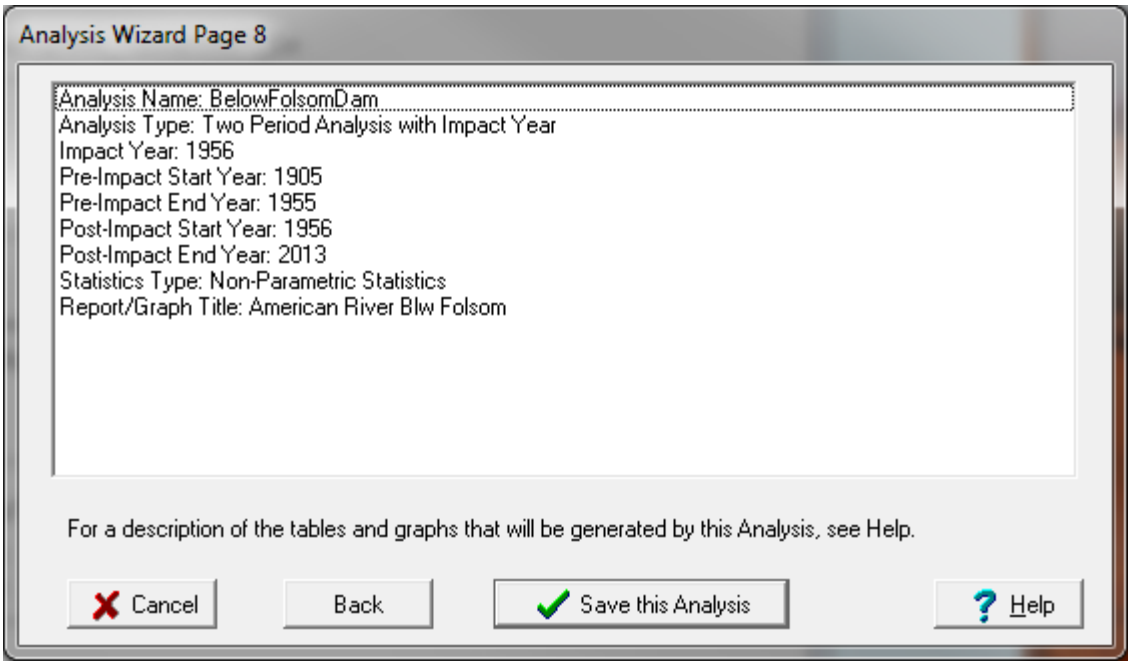

Analysis Wizard Page 8
Analysis Name: BelowFolsomDam
Analysis Type: Two Period Analysis with Impact Year
Impact Year: 1956
Pre-Impact Start Year: 1905
Pre-Impact End Year: 1955
Post-Impact Start Year: 1956
Post-Impact End Year: 2013
Statistics Type: Non-Parametric Statistics
Report/Graph Title: American River Blw Folsom
For a description of the tables and graphs that will be generated by this Analysis, see Help.
Cancel
Back
Save this Analysis
Help

Figure 21

• **STEP 6.** Click OK to run the analysis.

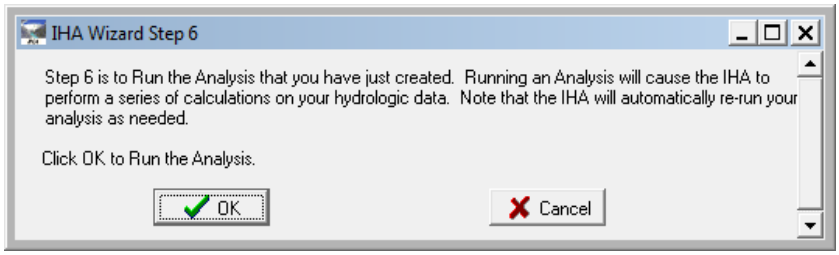

IHA Wizard Step 6
Step 6 is to Run the Analysis that you have just created. Running an Analysis will cause the IHA to perform a series of calculations on your hydrologic data. Note that the IHA will automatically re-run your analysis as needed.
Click OK to Run the Analysis.
OK
Cancel

Figure 22

You have now completed a basic analysis.

• **STEP 7.** Click OK to display the analysis output.

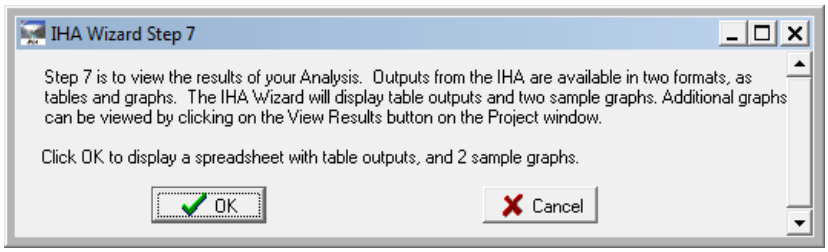

IHA Wizard Step 7
Step 7 is to view the results of your Analysis. Outputs from the IHA are available in two formats, as tables and graphs. The IHA Wizard will display table outputs and two sample graphs. Additional graphs can be viewed by clicking on the View Results button on the Project window.
Click OK to display a spreadsheet with table outputs, and 2 sample graphs.
OK
Cancel

Figure 23

Data Interpretation

This section will walk you through a few key components of the analysis results, assessing the hydrologic impacts of construction of the Folsom Dam on the American River.

Entire Record Period

• Activate the graph window titled Environmental Flow Components.

You will see a graph like the one below showing a daily hydrograph. Flow for each day is grouped into one of five types of Environmental Flow Components (EFCs) (extreme low flows, low flows, high flow pulses, small floods, large floods). Notice the difference in frequency of flows before and after the Folsom Dam was built in 1956.

For more information on Environmental Flow Components, please refer to the book, Rivers for Life by Postel and Richter (pg 49) and the IHA User Manual (pgs 13-15).

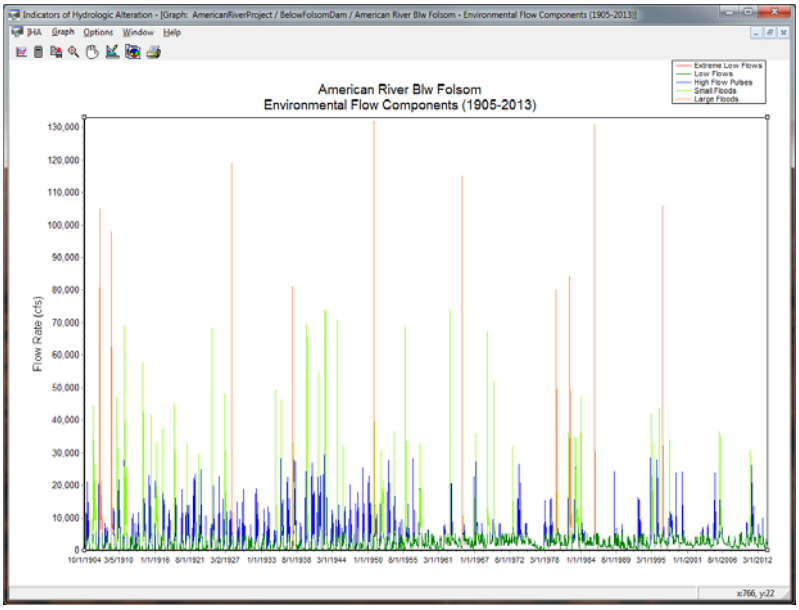


Figure 24

Unimpaired Flow Regime: Pre-dam

• Let's examine the pre-dam period. Select the Zoom tool (magnifying glass) and draw a rectangle over the hydrograph between 1912-1927.

To be turned in:

- Display a figure like figure 25.
- Notice the shape of the annual hydrographs. Do you notice something different during the period 1923-1924? Any guesses why?
- Describe how this graphic relates to Figure 2-4 of Rivers for life.
- If you zoom in to an specific year, let say 1924, does this figure is similar to figure 1-4 of rivers for life? What Flow elements are present in this hydrograph?

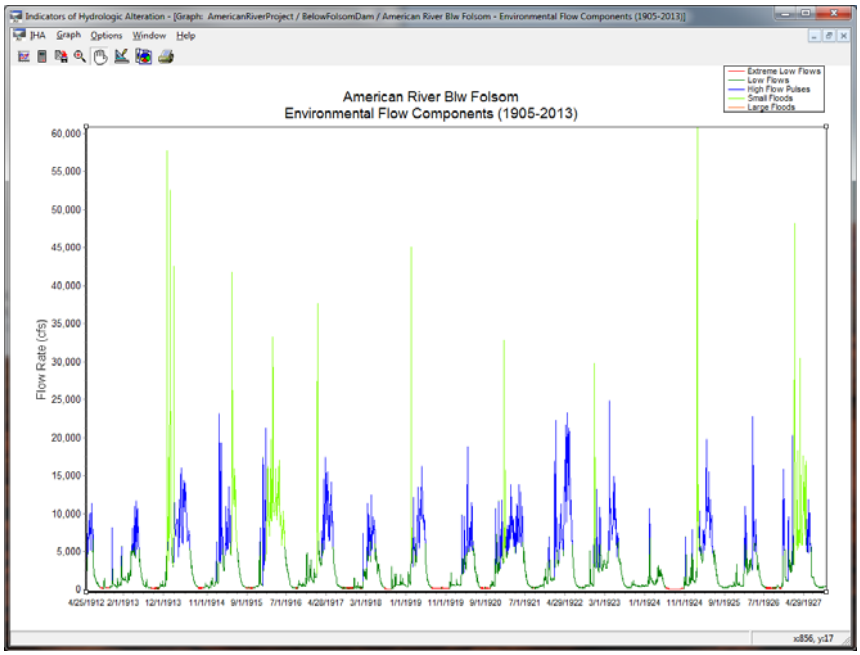


Figure 25

Now we will examine the parameters that were used to calculate the Environmental Flow Components. From the Graph menu, select Edit Analysis Parameters.

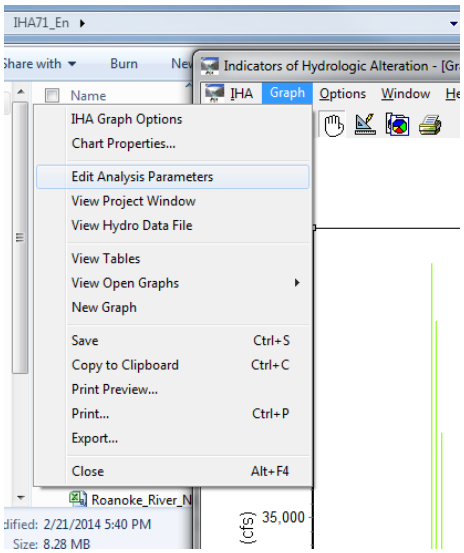


Figure 26

The follow window warns you that certain parameters can't be changed with the graphs opened.

• Click OK to continue.

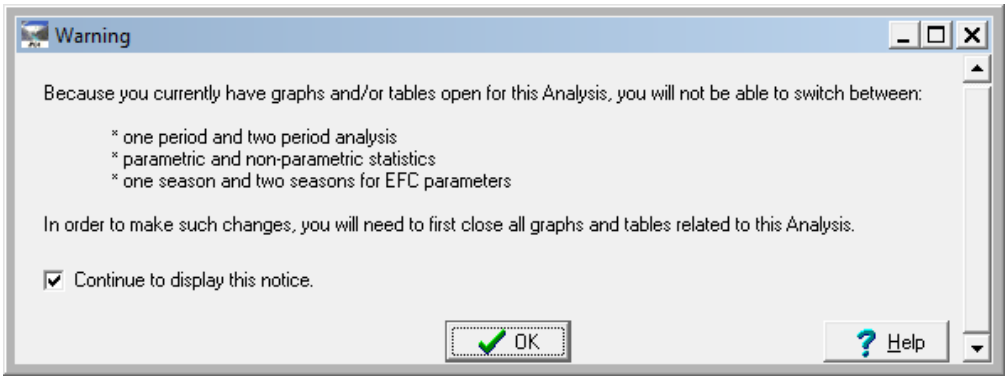

Warning
Because you currently have graphs and/or tables open for this Analysis, you will not be able to switch between:
* one period and two period analysis
* parametric and non-parametric statistics
* one season and two seasons for EFC parameters
In order to make such changes, you will need to first close all graphs and tables related to this Analysis.
Continue to display this notice.
OK
Help

Figure 27

• In the Analysis Properties window, activate the Environmental Flow Components tab.

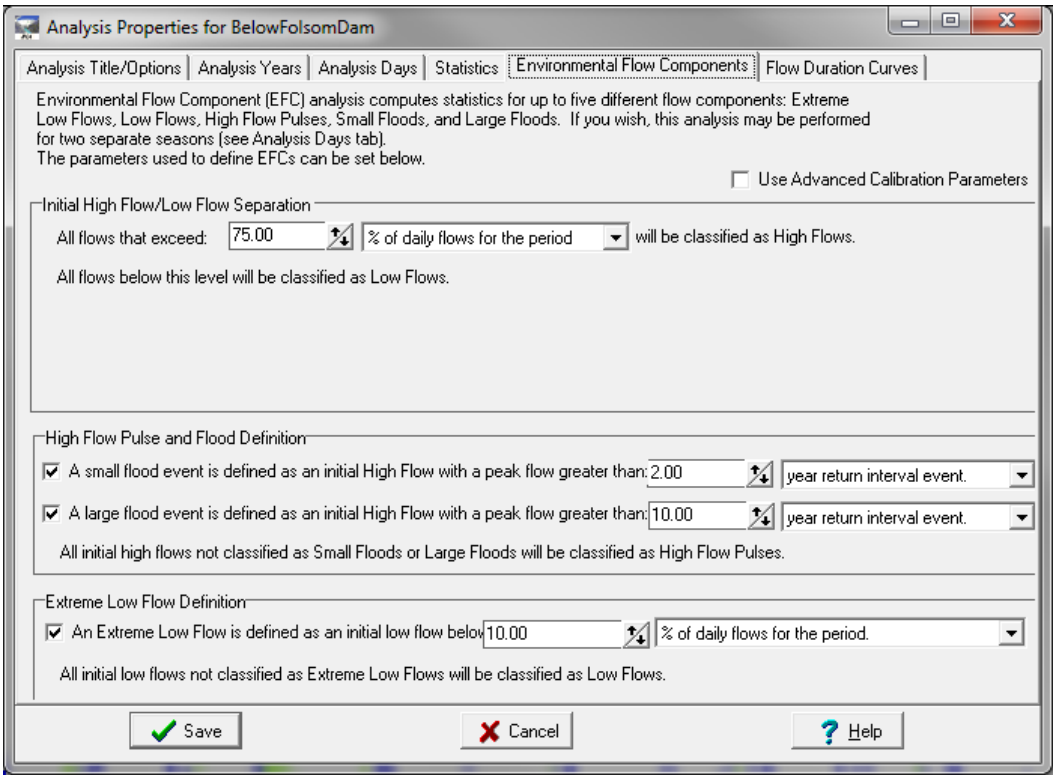

Analysis Properties for BelowFolsomDam
Analysis Title/Options
Analysis Years
Analysis Days
Statistics
Environmental Flow Components
Flow Duration Curves
Environmental Flow Component (EFC) analysis computes statistics for up to five different flow components: Extreme Low Flows, Low Flows, High Flow Pulses, Small Floods, and Large Floods. If you wish, this analysis may be performed for two separate seasons (see Analysis Days tab).
The parameters used to define EFCs can be set below.
Use Advanced Calibration Parameters
Initial High Flow/Low Flow Separation
All flows that exceed: 75.00 % of daily flows for the period will be classified as High Flows.
All flows below this level will be classified as Low Flows.
High Flow Pulse and Flood Definition
A small flood event is defined as an initial High Flow with a peak flow greater than: 2.00 year return interval event.
A large flood event is defined as an initial High Flow with a peak flow greater than: 10.00 year return interval event.
All initial high flows not classified as Small Floods or Large Floods will be classified as High Flow Pulses.
Extreme Low Flow Definition
An Extreme Low Flow is defined as an initial low flow below 10.00 % of daily flows for the period.
All initial low flows not classified as Extreme Low Flows will be classified as Low Flows.
Save
Cancel
Help

Figure 28

The Environmental Flow Components tab allows you to modify parameters used in the algorithm that calculates Environmental Flow Components, such as how small and large flood events are defined.

• Click Cancel to return to the graph.

Impaired Flow Regime: Post-dam

Select the Zoom Out to Full Extent button (magnifying glass) to see the entire flow record. Draw a rectangle around the hydrograph between 1966-1979. Note that the base flow is considerably higher than in the pre-dam hydrographs. This is due to water releases from the Folsom Reservoir.

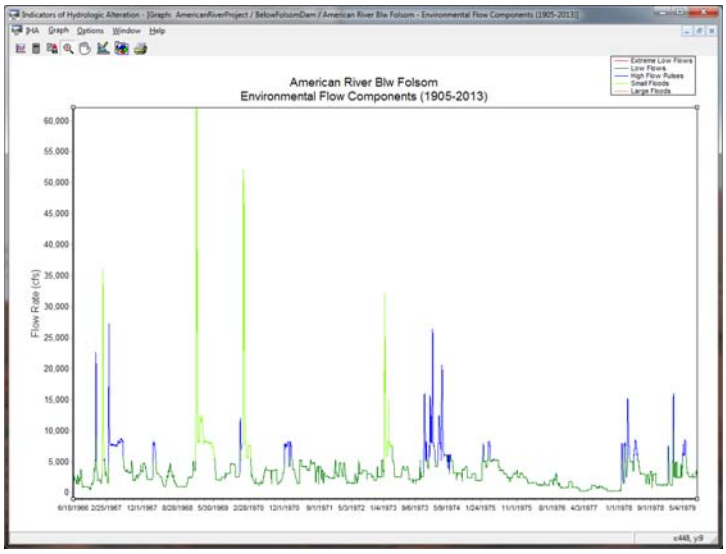


Figure 29

To be turned in:

- A graph like Figure 29 from 1966 to 1979
- Could you explain why the flow pattern is different that Figure 25. What flow elements are missing? Which flow elements are more abundant? Take a look at Figure 1-5 and 4-2 of Rivers for life

Transition

Now take a look at the hydrograph around 1956. Notice how the flows transition from pre-dam to post-dam flow regimes.

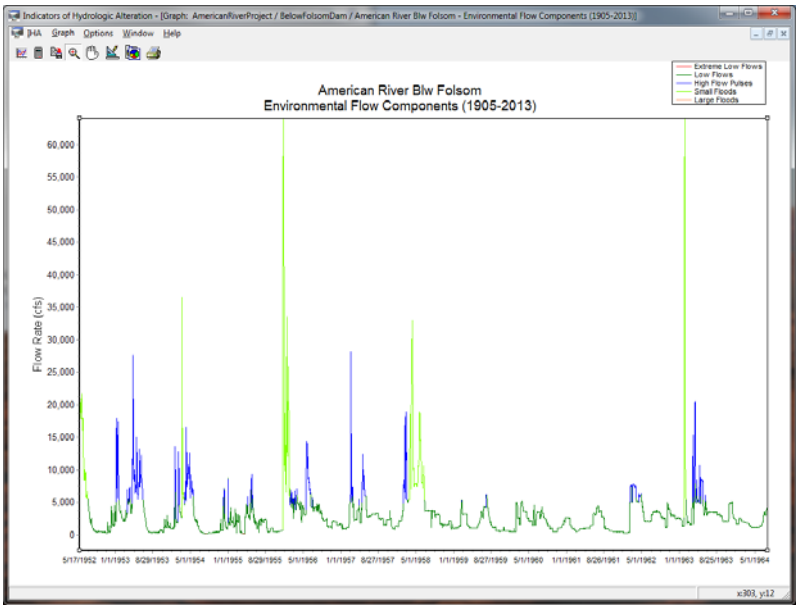


Figure 30

To be turned in:

- A graph like Figure 30 from 1956 to 1964
- Why are the changes in flow regime from 1956 to 1964. What is altering the flow regime? What type of flow elements are missing and what ecological functions these flow elements were providing (See figure 2-4, Box 2-1 at page 49 of Rivers for life)?

Annual unimpaired hydrograph

Figure 31 is close up view of the annual hydrograph for water year 1916.

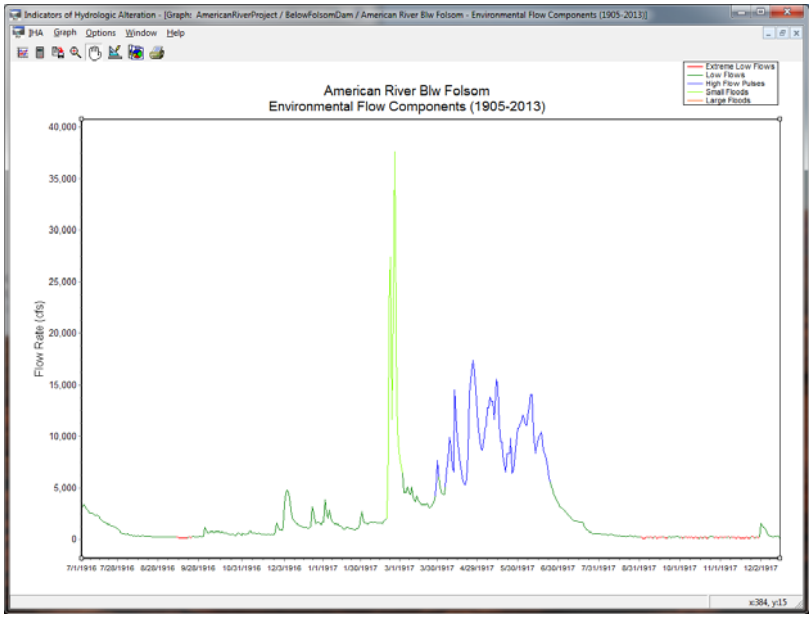


Figure 31

To be turned in:

- A graph like figure 31. Does this hydrograph is similar to Fugure 2-3 of Rivers for life? Why?
- Can you identify a seasonal pattern? During summer, fall, winter and spring? What elements are presents during every seasons (See figure 2-3)? What ecological functions (Box 2-1 at page 49 of Rivers for life) these flow regimes were providing?

Annual impaired hydrograph

Figures 32 and 33 are annual hydrographs for water years 1970 and 1972, respectively.

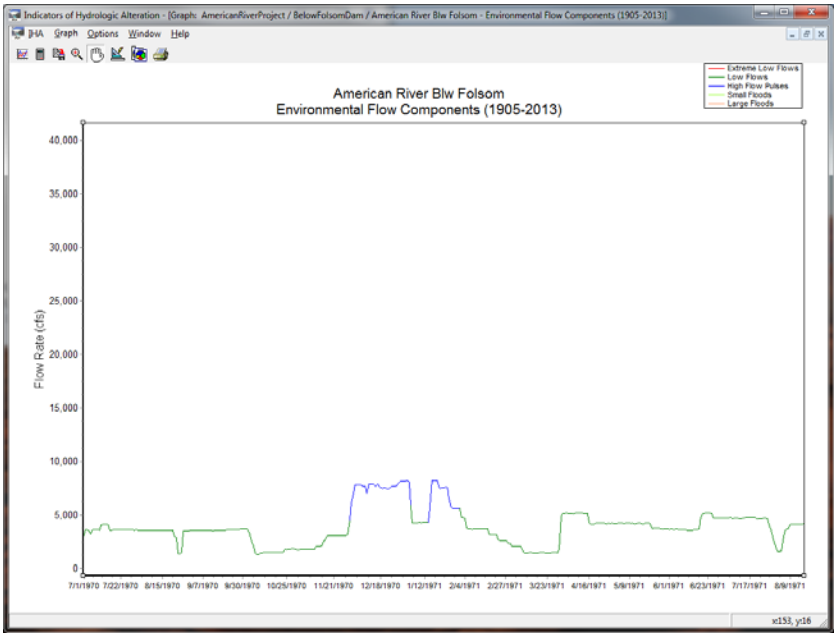


Figure 32

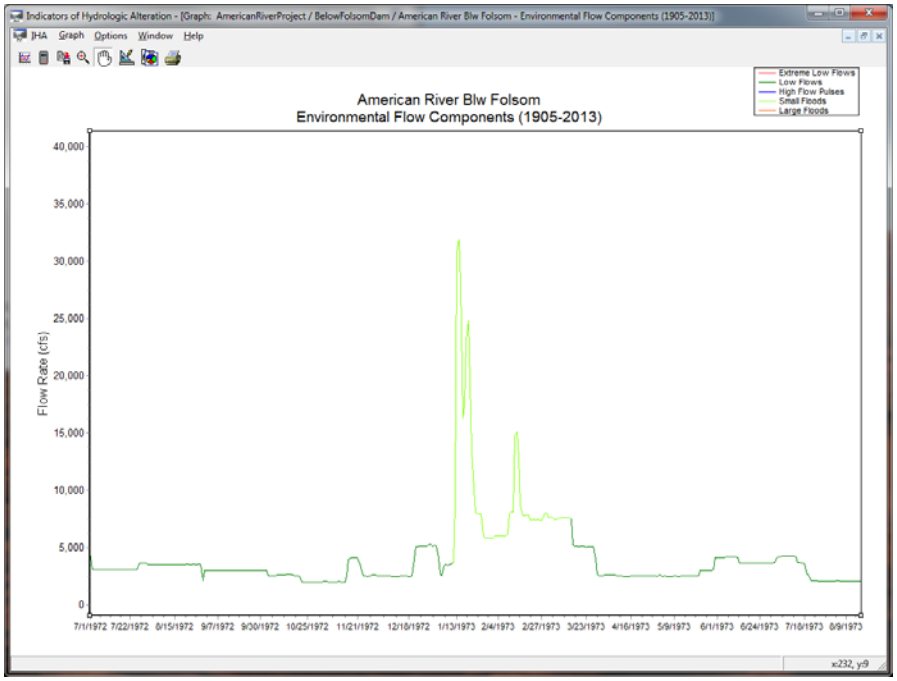


Figure 33

Now, lets compare the pre- and post- dam hydrographs.

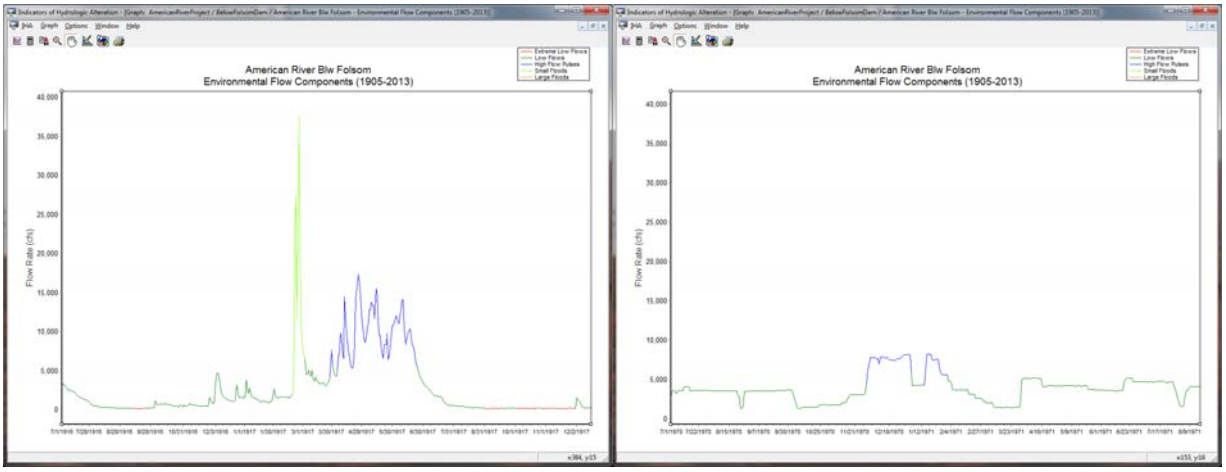


Figure 34

Pre-Reservoir Vs. Post-Reservoir

Figure 35 (left) is close up for the annual hydrograph for the 1976 water year, which is during a dry period that spanned two years. The right hydrograph is during the drought of 1923.

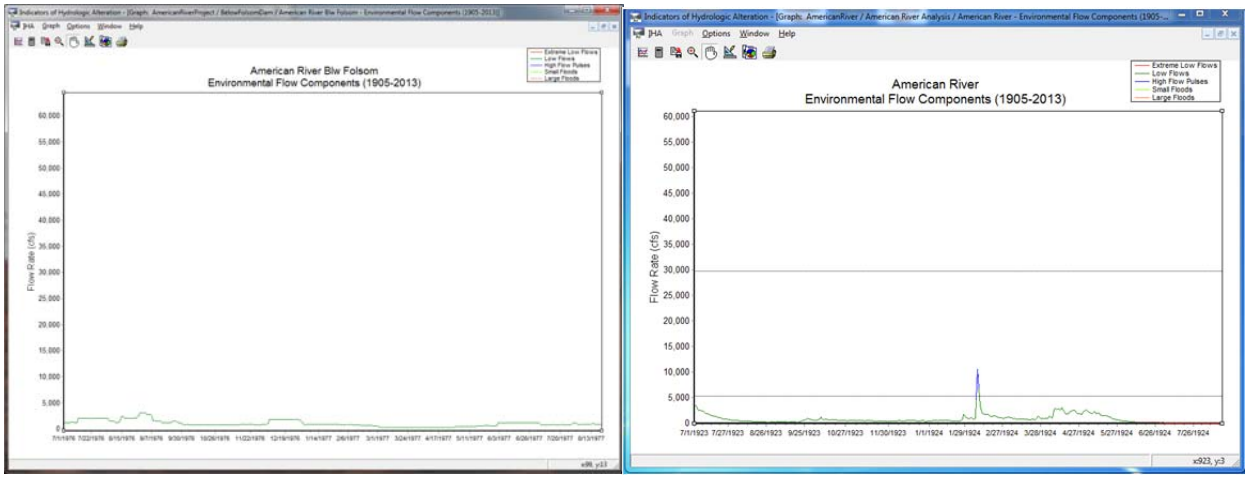


Figure 35: Post-dam dry period (left), Pre-dam dry period (right)

To be turned in:

- A graph like figure 34. Can you discuss if this figure is similar to Figure 4-2 of rivers for life? What is the reservoir doing to the flow? Do you think is affecting the aquatic ecosystem of the river?

Comparing Monthly Median

Activate the graph window Monthly Flow for October and notice the median flows of pre- and post- dam flows.

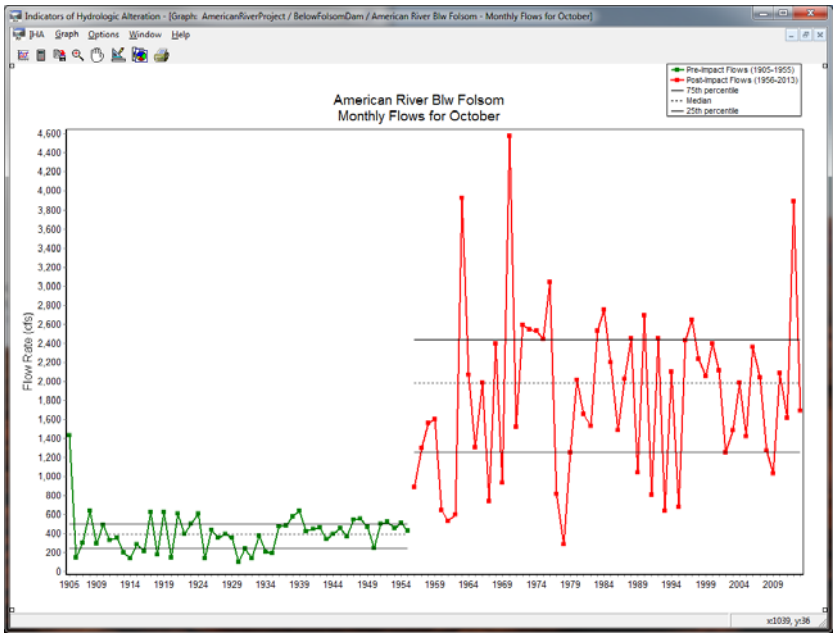


Figure 36

• Click on the IHA Graph Options button (leftmost) and select March.

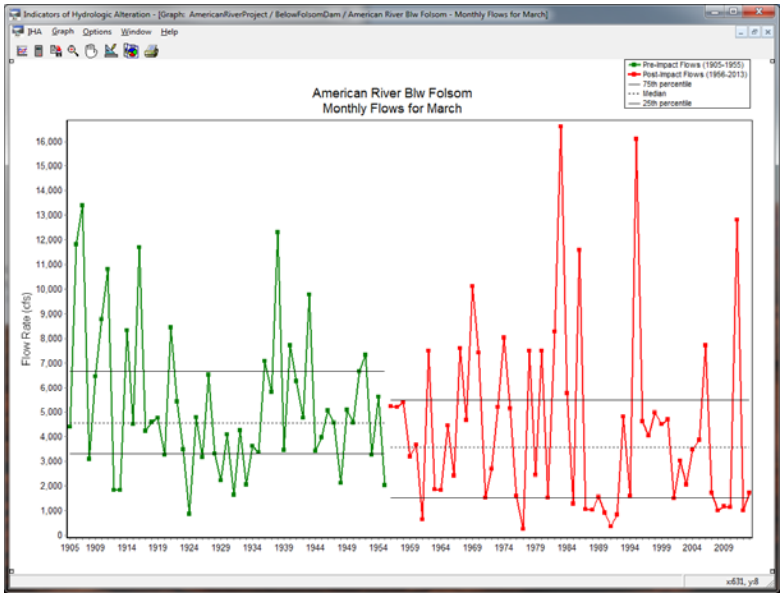


Figure 37

To be turned in:

- A graph like Figure 36. What is happening with the median flow of October in the American River? Has it changed after the reservoir construction?

Flow Duration Curves

Activate the graph window for Flow Duration Curves.

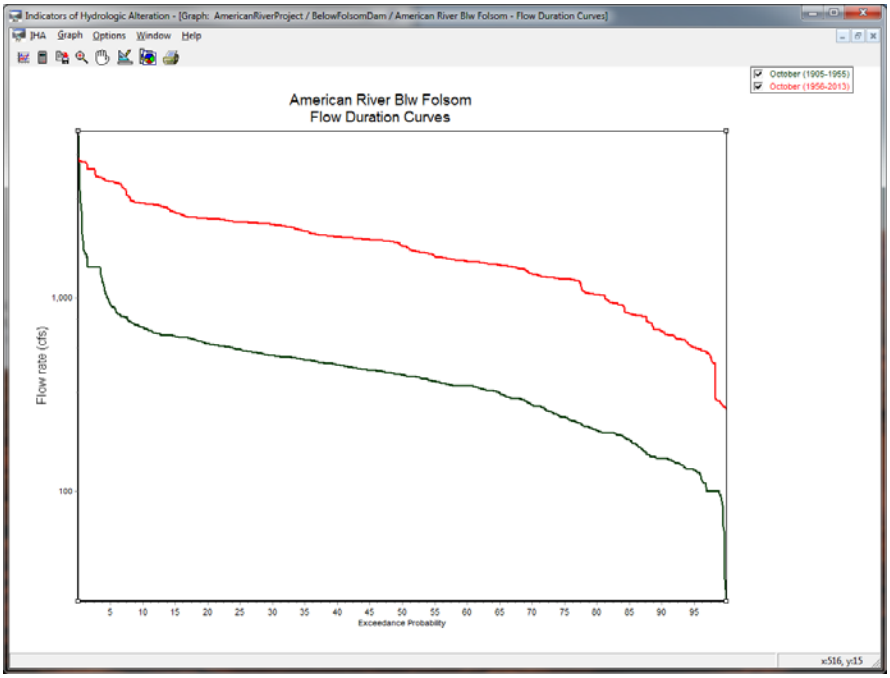

Indicators of Hydrologic Alteration - [Graph: AmericanRiverProject / BelowFolsomDam / American River Blw Folsom - Flow Duration Curves]
IHA Graph Options Window Help
October (1905-1955)
October (1956-2013)
American River Blw Folsom
Flow Duration Curves
Flow rate (cfs)
1,000
100
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
Exceedance Probability
x:516, y:15

Figure 38

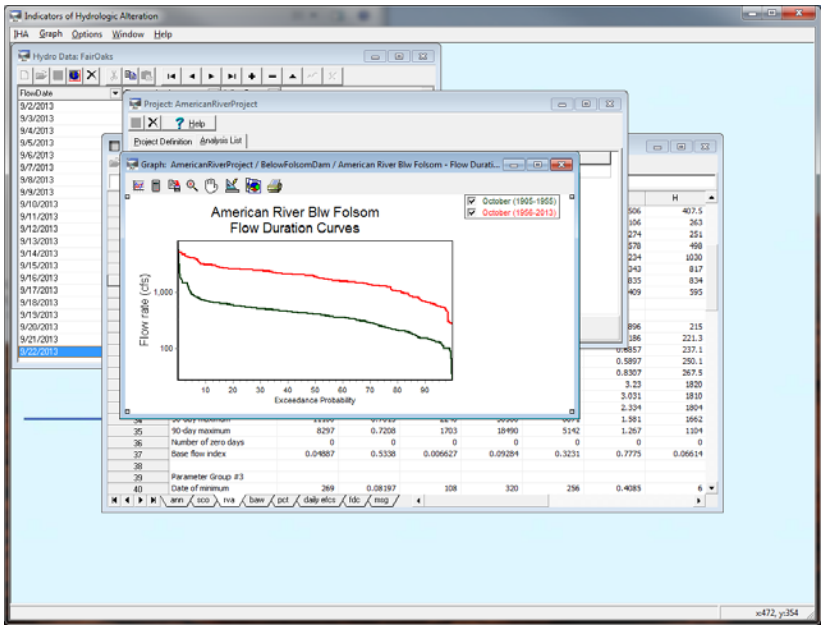


Figure 39

• Activate the Project window. Right click on View Results and select View Tables.

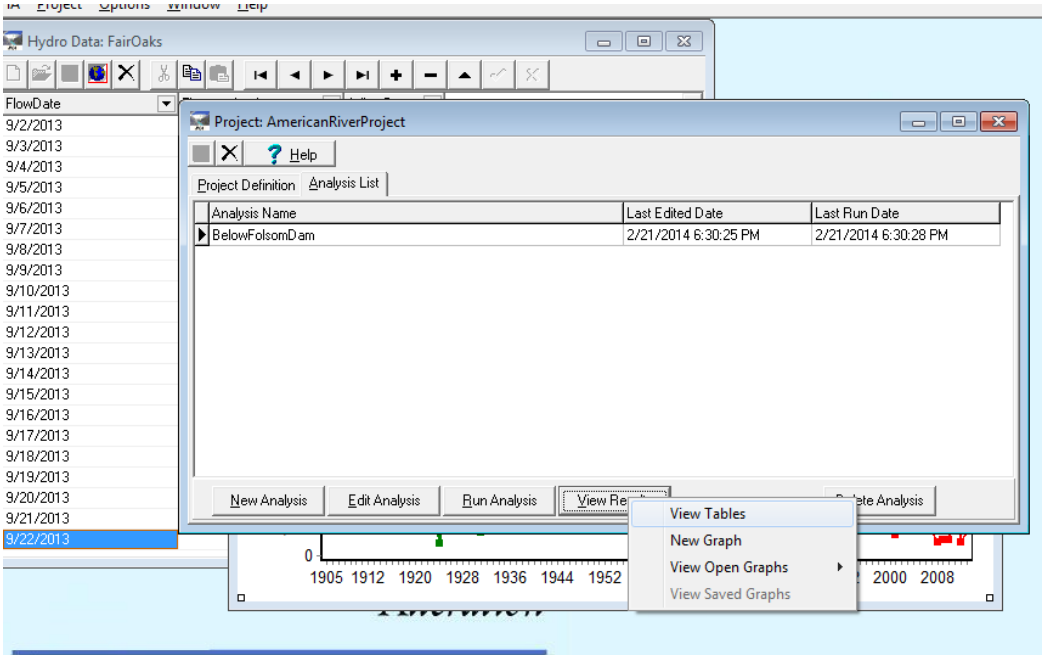
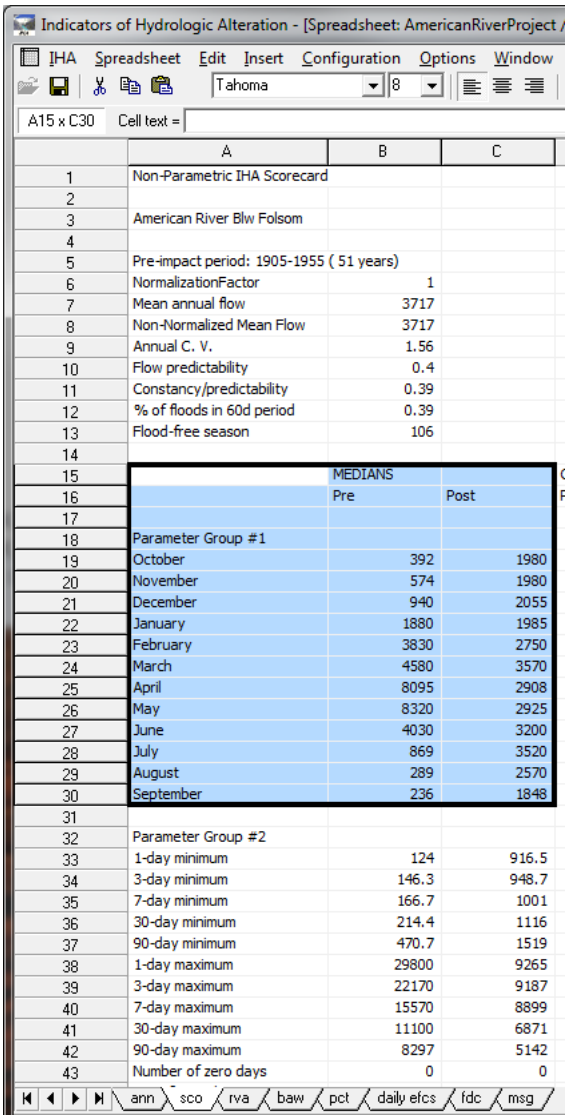


Figure 40

• Select the sco worksheet to see the median pre- and post- dam flow values.

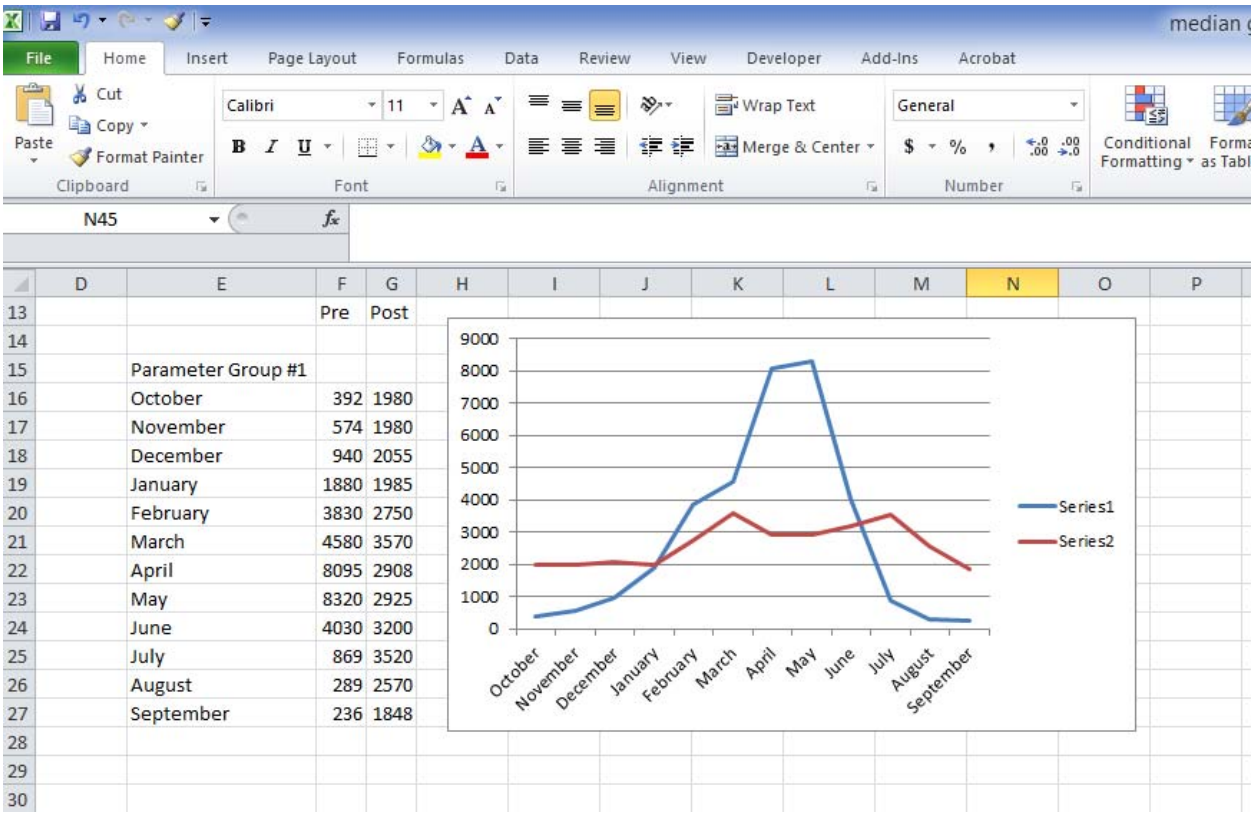

Indicators of Hydrologic Alteration - [Spreadsheet: AmericanRiverProject
IHA Spreadsheet Edit Insert Configuration Options Window
Tahoma 8
A15 x C30 Cell text =

	A	B	C
1	Non-Parametric IHA Scorecard		
2			
3	American River Blw Folsom		
4			
5	Pre-impact period: 1905-1955 (51 years)		
6	NormalizationFactor	1	
7	Mean annual flow	3717	
8	Non-Normalized Mean Flow	3717	
9	Annual C. V.	1.56	
10	Flow predictability	0.4	
11	Constancy/predictability	0.39	
12	% of floods in 60d period	0.39	
13	Flood-free season	106	
14			
15		MEDIANS	
16		Pre	Post
17			
18	Parameter Group #1		
19	October	392	1980
20	November	574	1980
21	December	940	2055
22	January	1880	1985
23	February	3830	2750
24	March	4580	3570
25	April	8095	2908
26	May	8320	2925
27	June	4030	3200
28	July	869	3520
29	August	289	2570
30	September	236	1848
31			
32	Parameter Group #2		
33	1-day minimum	124	916.5
34	3-day minimum	146.3	948.7
35	7-day minimum	166.7	1001
36	30-day minimum	214.4	1116
37	90-day minimum	470.7	1519
38	1-day maximum	29800	9265
39	3-day maximum	22170	9187
40	7-day maximum	15570	8899
41	30-day maximum	11100	6871
42	90-day maximum	8297	5142
43	Number of zero days	0	0

Figure 41

To be turned in:

- Export the data highlighted in Figure 41 to excel and create a graphic like the following. How the median flows has changed? Has it shifted? Has it been reduced?


median
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Developer
Add-Ins
Acrobat
Cut
Copy
Format Painter
Paste
Clipboard
Calibri
11
Font
Wrap Text
Merge & Center
Alignment
General
Number
Conditional Formatting
N45
Pre
Post
Parameter Group #1
October 392 1980
November 574 1980
December 940 2055
January 1880 1985
February 3830 2750
March 4580 3570
April 8095 2908
May 8320 2925
June 4030 3200
July 869 3520
August 289 2570
September 236 1848
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
October
November
December
January
February
March
April
May
June
July
August
September
Series1
Series2